EMBEDDED LINUX CONFERENCE

@

THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
EUROPE

SBOMs: Essential for Embedded too!

Kate Stewart, VP Dependable Embedded Systems

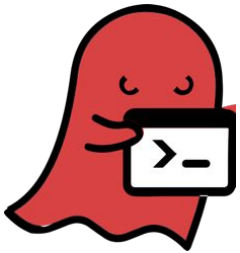
#ossummit @_kate_stewart

THE LINUX FOUNDATION

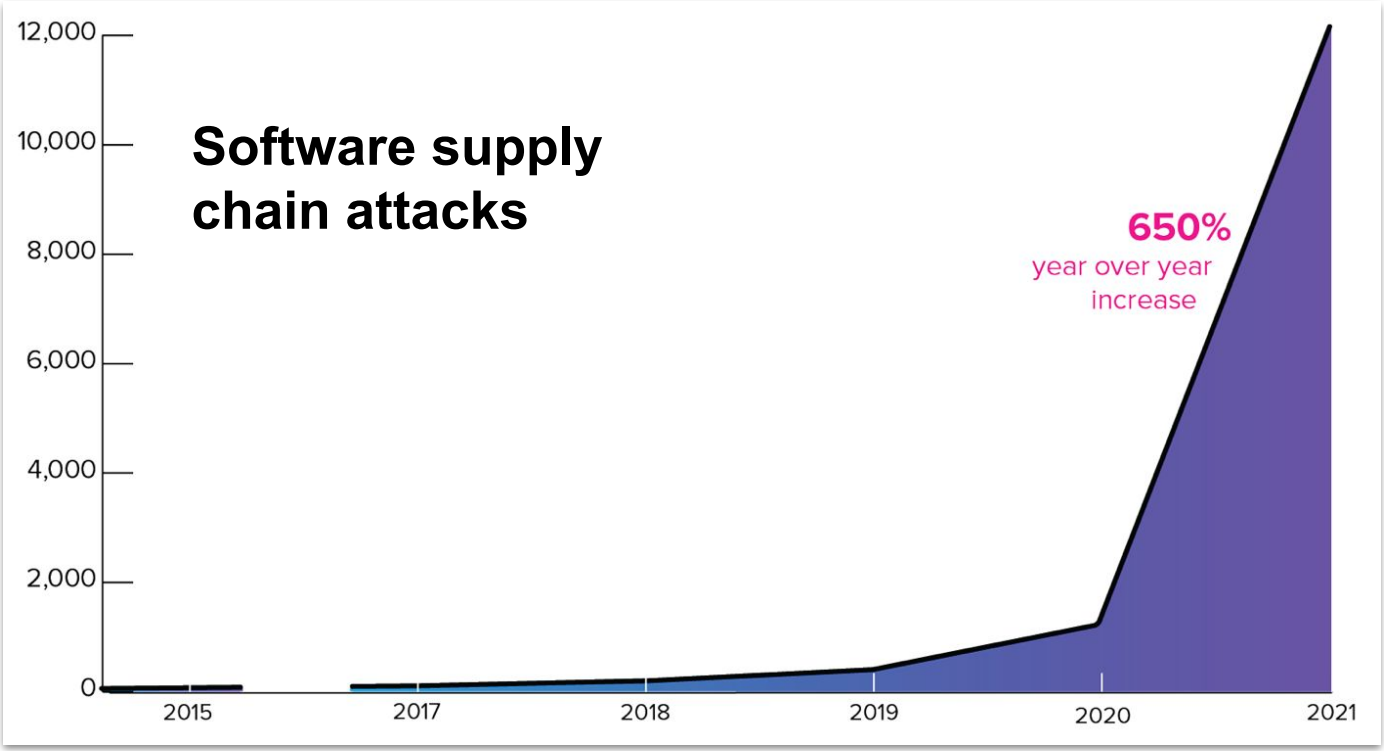
- **Why the interest in SBOMs?**
- What makes up an SBOM?
- How to produce SBOMs for embedded systems?

Challenge:

Are my products affected by $vulnerability$?

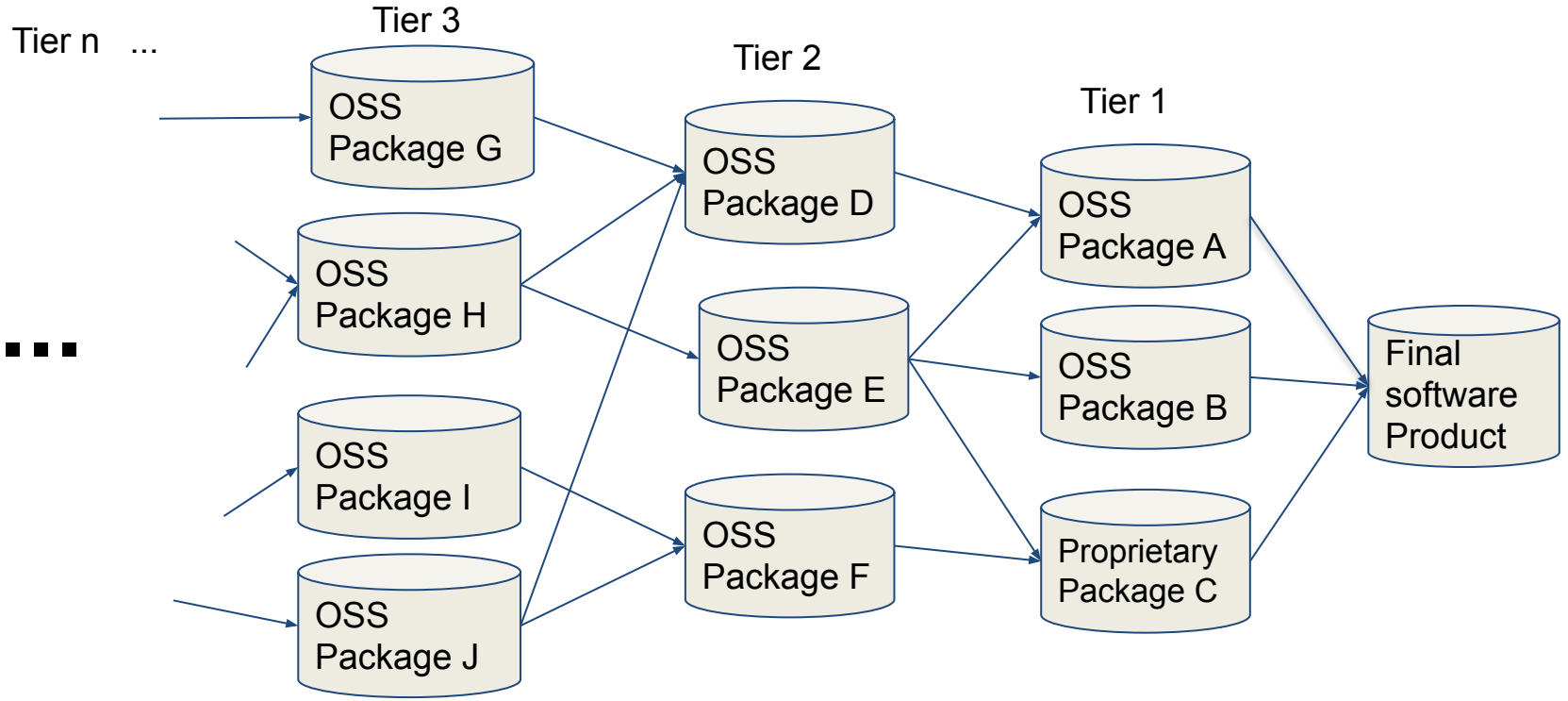


Software Supply Chain Attacks are Growing…



Sources: Sonatype 2021 State of the Software Supply Chain

What is the Software Supply Chain?



Set of **software**, **suppliers**, **development processes**, and **distribution processes** used to **create software products**

Cost to Remediate?

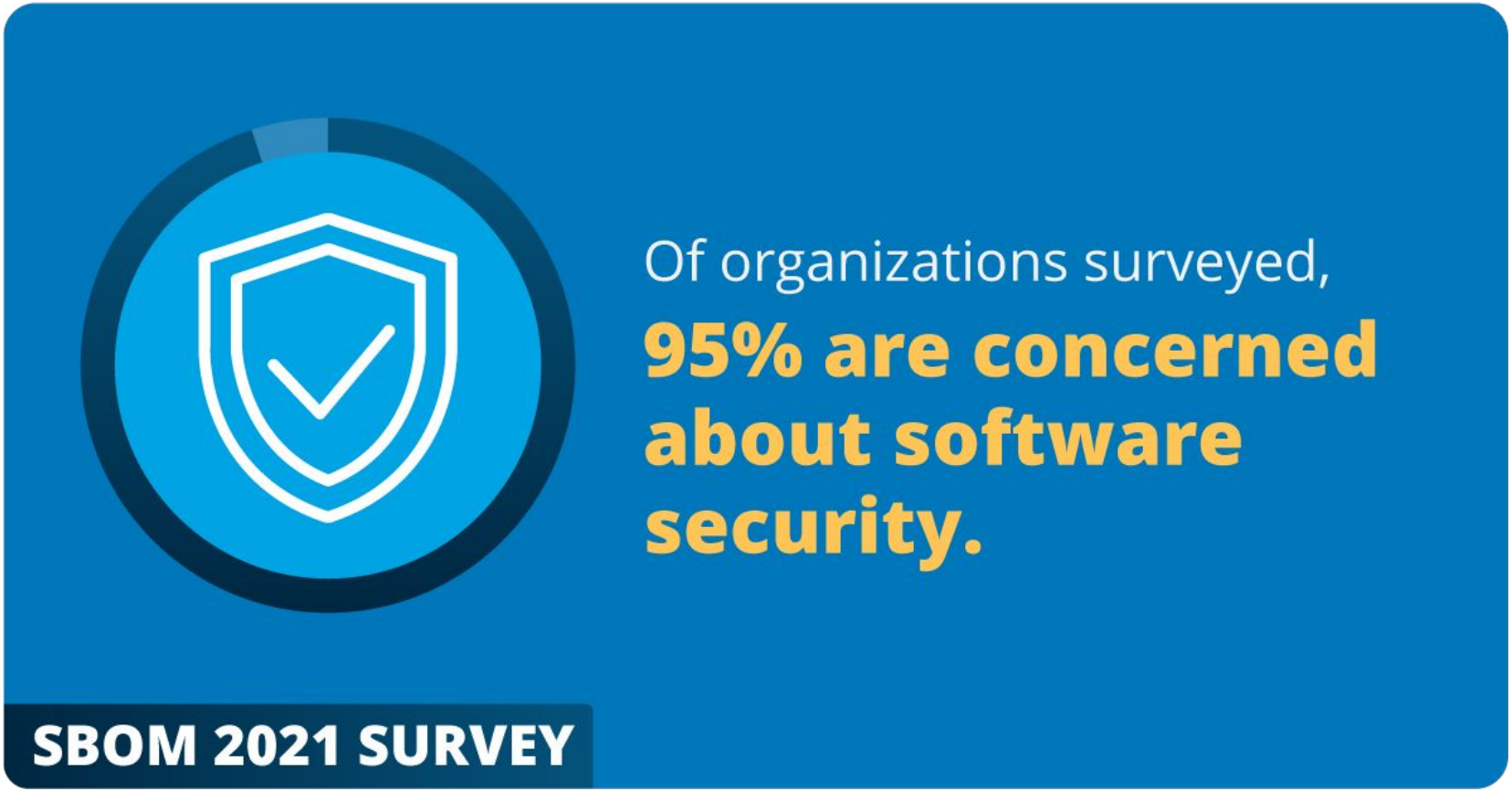
Cost to developers to fix is small, cost to users....

Source: https://www.itpro.co.uk/security/cyber-security/358064/flaws-in-open-source-protocols-expose-millions-of-embedded-devices

Source: https://www.rollcall.com/2021/01/11/cleaning-up-solarwinds-hack-may-cost-as-much-as-100-billion/

Source:https://www.ftc.gov/news-events/blogs/techftc/2022/01/ftc-warns-companies-remediate-log4j-security-vulnerability

THE LINUX FOUNDATION

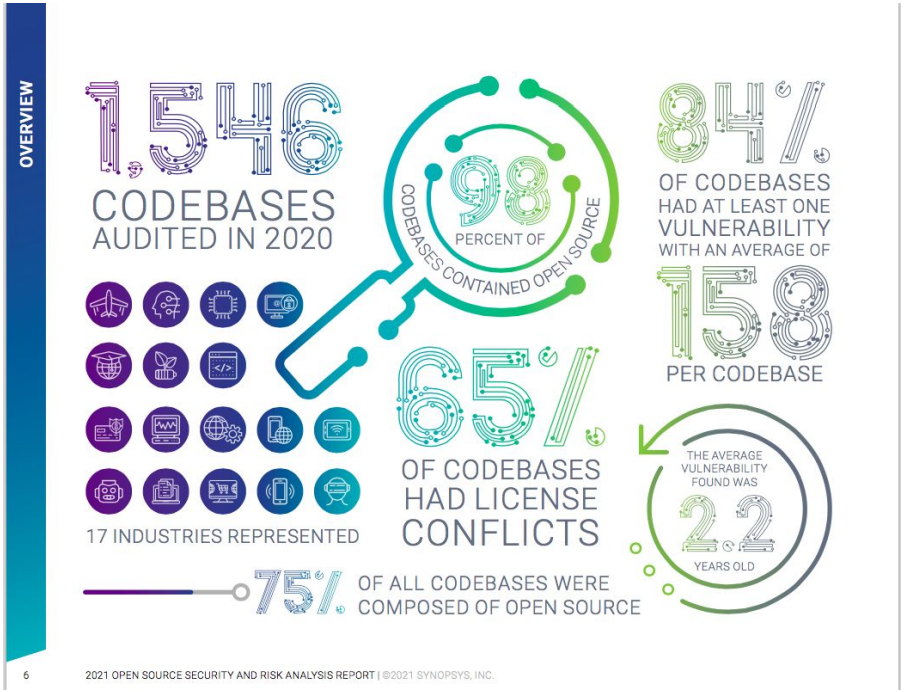


Source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/

Source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/

“98% of codebases audited in 2020 contained open source components.

Open source made up 75% of the audited codebases.”



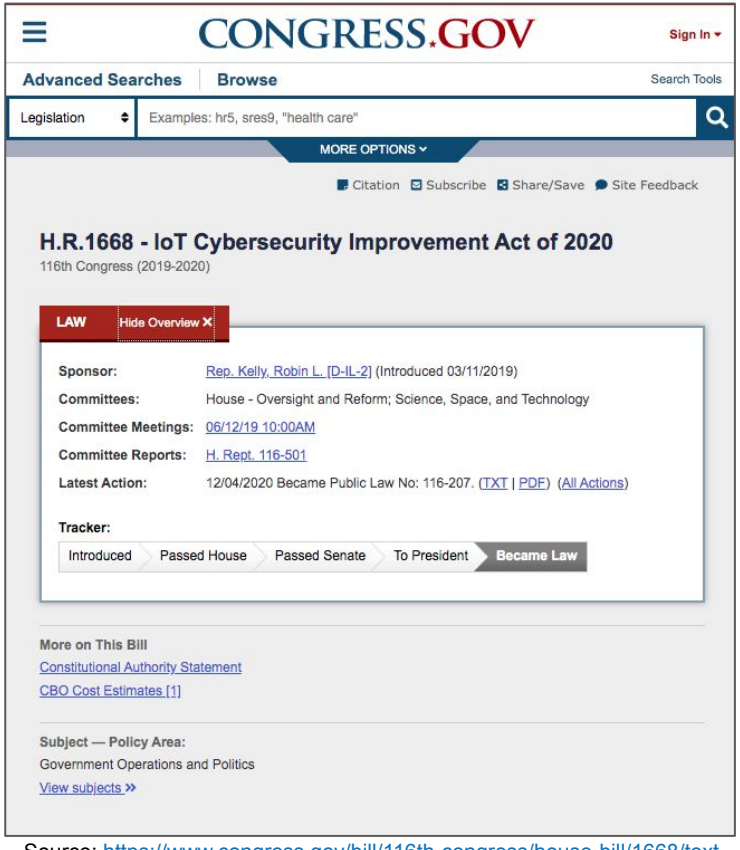
Source: [2021 Synopsys Open Source Security and Risk Analysis Report]

Transparency is key to improving supply chain security!

Source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/

Guidelines and Legislation ...

Source: www.enisa.europa.eu/publications/guidelines-for-securing-the-internet-of-things



Source: https://www.congress.gov/bill/116th-congress/house-bill/1668/text

Regulatory Agencies …

CYBERSECURITY NEWS

Healthcare Sector Spearheads SBOM Adoption to Support Cybersecurity

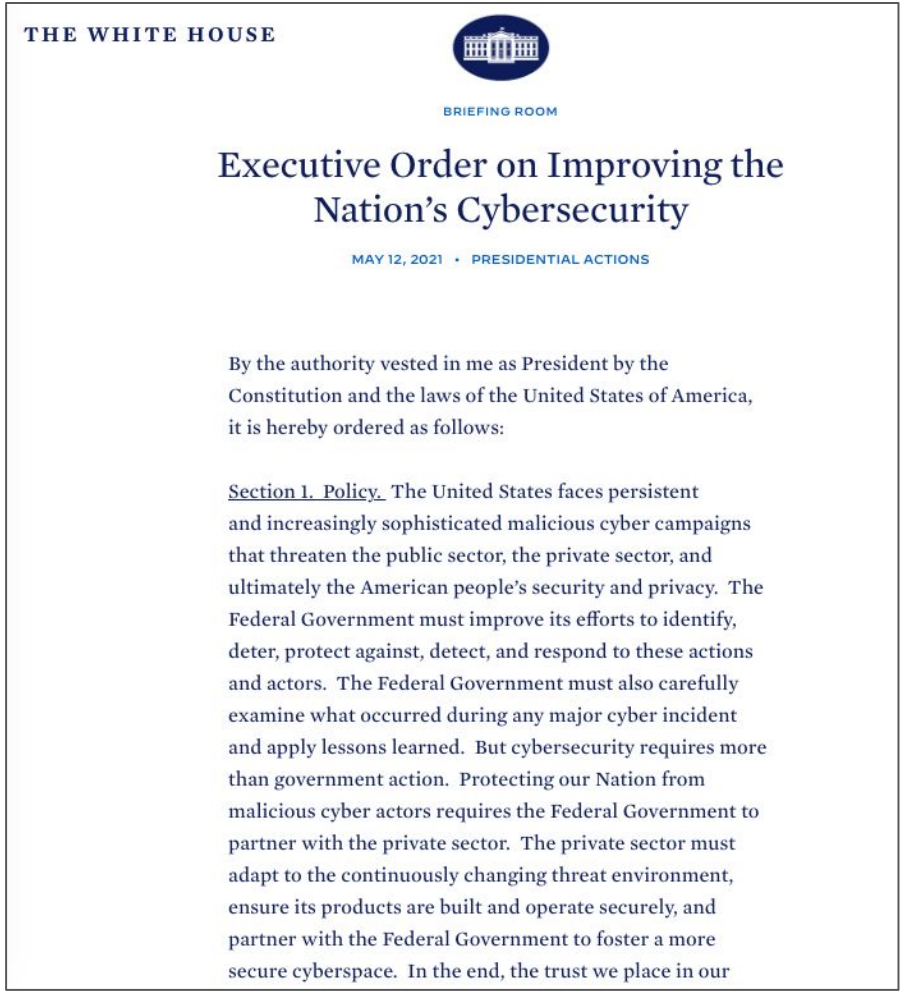
Healthcare is pioneering SBOM adoption due to growing cybersecurity concerns and the FDA's recent medical device security guidance, the Linux Foundation found.

Source:https://healthitsecurity.com/news/healthcare-sector-spearheads-sbom-adoption-to-support-cybersecurity

9 rules imposed by NERC CIP standards

CIP-001	Sabotage reporting
CIP-002	Critical cyber asset identification
CIP-003	Security management controls
CIP-004	Personnel and training
CIP-005	Electronic security perimeters
CIP-006	Physical security of critical cyber assets
CIP-007	Systems security management
CIP-008	Incident reporting and response planning
CIP-009	Recovery plans for critical cyber assets

Source:https://searchcompliance.techtarget.com/definition/NERC-CIP-critical-infrastructure-protection



THE WHITE HOUSE

BRIEFING ROOM

Executive Order on Improving the Nation's Cybersecurity

MAY 12, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

Section 1. Policy. The United States faces persistent and increasingly sophisticated malicious cyber campaigns that threaten the public sector, the private sector, and ultimately the American people's security and privacy. The Federal Government must improve its efforts to identify, deter, protect against, detect, and respond to these actions and actors. The Federal Government must also carefully examine what occurred during any major cyber incident and apply lessons learned. But cybersecurity requires more than government action. Protecting our Nation from malicious cyber actors requires the Federal Government to partner with the private sector. The private sector must adapt to the continuously changing threat environment, ensure its products are built and operate securely, and partner with the Federal Government to foster a more secure cyberspace. In the end, the trust we place in our

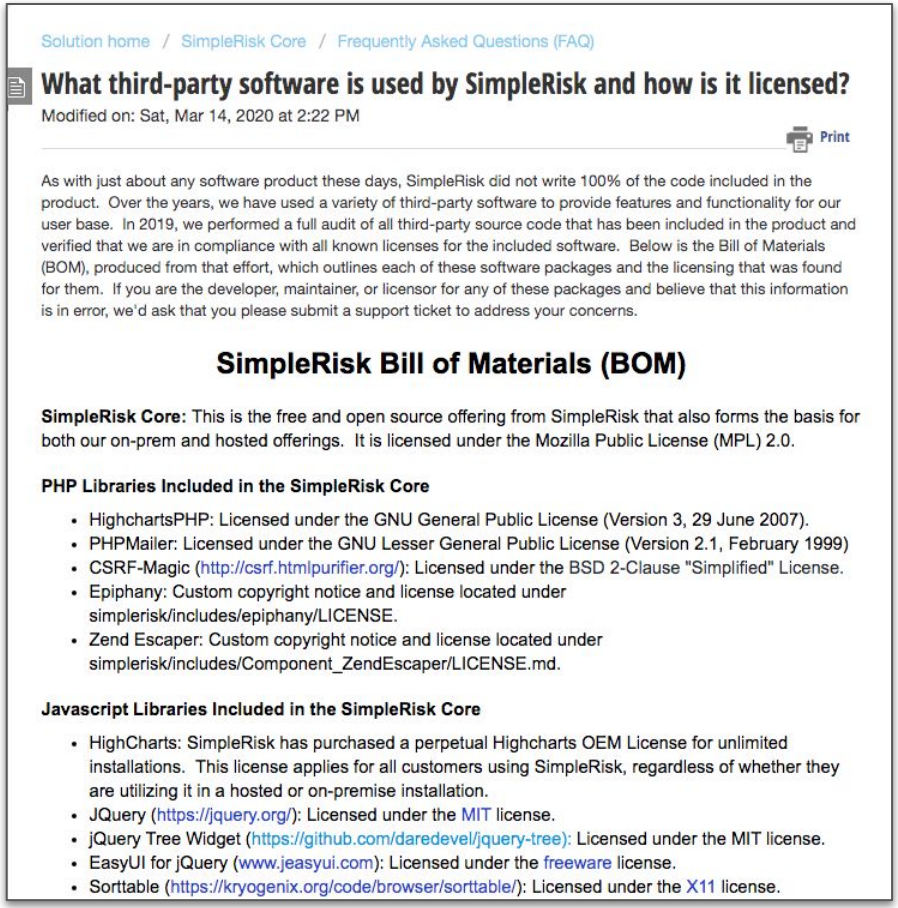
Source:https://www.whitehouse.gov/briefing-room/presidential-actions/2021/05/12/executive-order-on-improving-the-nations-cybersecurity/

- Why the interest in SBOMs?
- **What makes up an SBOM?**
- How to produce SBOMs for Embedded Systems?

What do SBOM's look like?

Lots of different forms…

Need to standardize to automate at scale.



Solution home / SimpleRisk Core / Frequently Asked Questions (FAQ)

What third-party software is used by SimpleRisk and how is it licensed?

Modified on: Sat, Mar 14, 2020 at 2:22 PM

Print

As with just about any software product these days, SimpleRisk did not write 100% of the code included in the product. Over the years, we have used a variety of third-party software to provide features and functionality for our user base. In 2019, we performed a full audit of all third-party source code that has been included in the product and verified that we are in compliance with all known licenses for the included software. Below is the Bill of Materials (BOM), produced from that effort, which outlines each of these software packages and the licensing that was found for them. If you are the developer, maintainer, or licensor for any of these packages and believe that this information is in error, we'd ask that you please submit a support ticket to address your concerns.

SimpleRisk Bill of Materials (BOM)

SimpleRisk Core: This is the free and open source offering from SimpleRisk that also forms the basis for both our on-prem and hosted offerings. It is licensed under the Mozilla Public License (MPL) 2.0.

PHP Libraries Included in the SimpleRisk Core

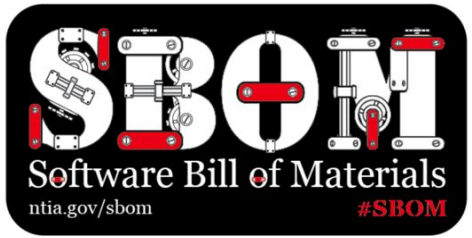
- HighchartsPHP: Licensed under the GNU General Public License (Version 3, 29 June 2007).
- PHPMailer: Licensed under the GNU Lesser General Public License (Version 2.1, February 1999)
- CSRF-Magic (http://csrf.htmlpurifier.org/): Licensed under the BSD 2-Clause "Simplified" License.
- Epiphany: Custom copyright notice and license located under simplerisk/includes/epiphany/LICENSE.
- Zend Escaper: Custom copyright notice and license located under simplerisk/includes/Component_ZendEscaper/LICENSE.md.

Javascript Libraries Included in the SimpleRisk Core

- HighCharts: SimpleRisk has purchased a perpetual Highcharts OEM License for unlimited installations. This license applies for all customers using SimpleRisk, regardless of whether they are utilizing it in a hosted or on-premise installation.
- JQuery (https://jquery.org/): Licensed under the MIT license.
- jQuery Tree Widget (https://github.com/daredevel/jquery-tree): Licensed under the MIT license.
- EasyUI for jQuery (www.jeasyui.com): Licensed under the freeware license.
- Sorttable (https://kryogenix.org/code/browser/sorttable/): Licensed under the X11 license.

Source:https://simplerisk.freshdesk.com/support/solutions/articles/6000230367-what-third-party-software-is-used-by-simplerisk-and-how-is-it-licensed-

Software Bill of Materials (SBOM)

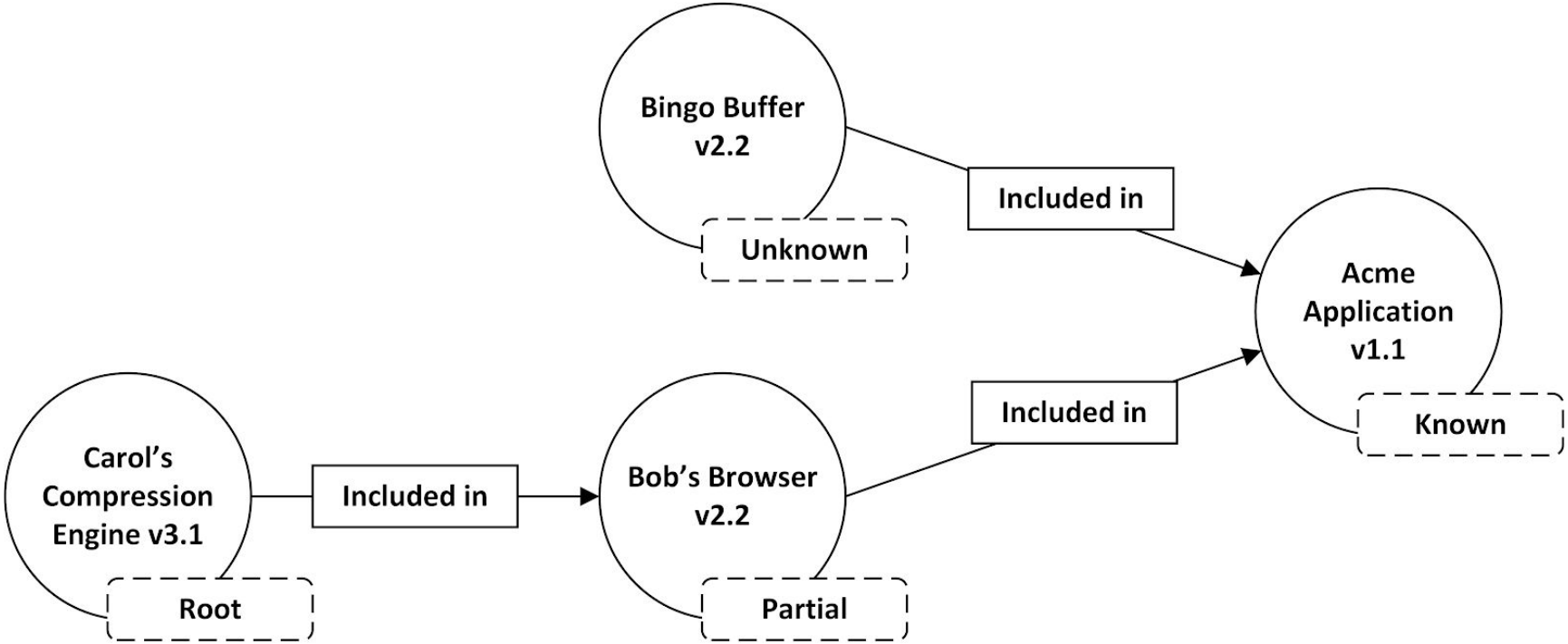


An SBOM is a formal record containing the details and supply chain relationships of various components used in building software.

These components, including libraries and modules, can be open source or proprietary, free or paid, and the data can be widely available or access-restricted.

Source: NTIA's SBOM FAQ

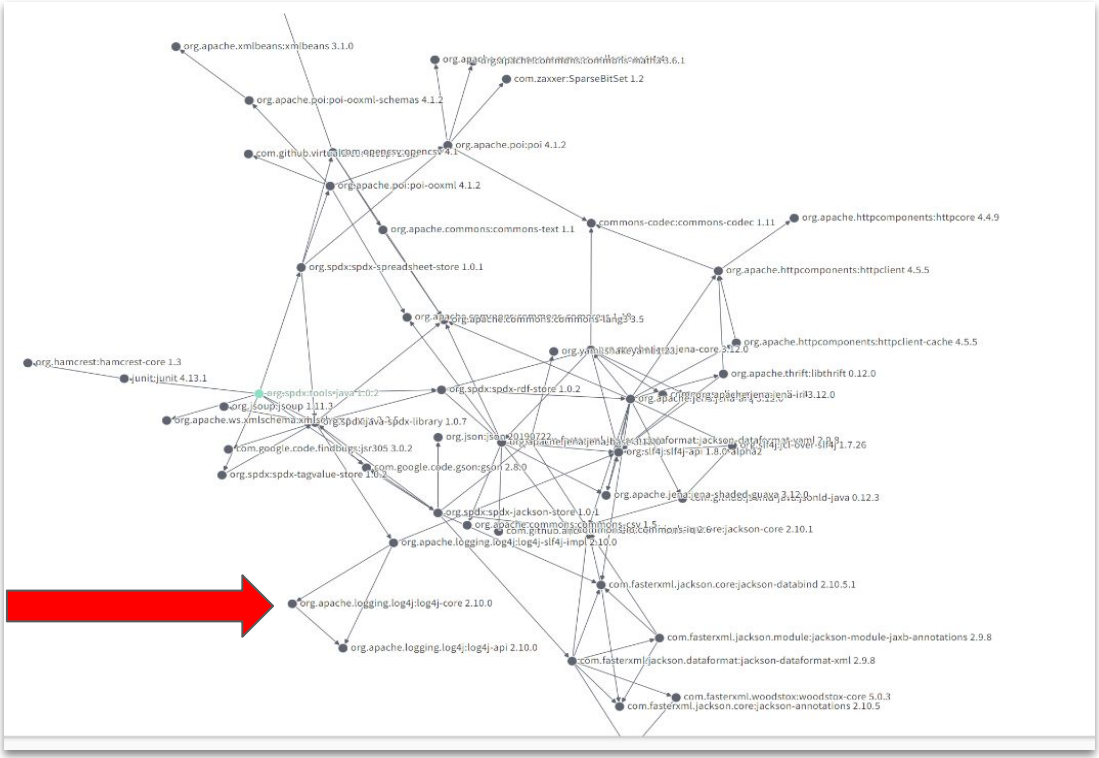
What does the SBOM represent?



Source: NTIA's [Framing Software Component Transparency: Establishing a Common Software Bill of Material (SBOM)]

Challenge: Finding vulnerability in complex software

- Need to search the full dependency graph
- Not all dependencies are the same, there are different dependency types (test, build tools, static linked …)
- No single “UPC code” to clearly identify packages



Source: https://deps.dev/maven/org.spdx%3Atools-java/1.0.2/dependencies/graph

Producing & Consuming SBOMs

upstream / supplier

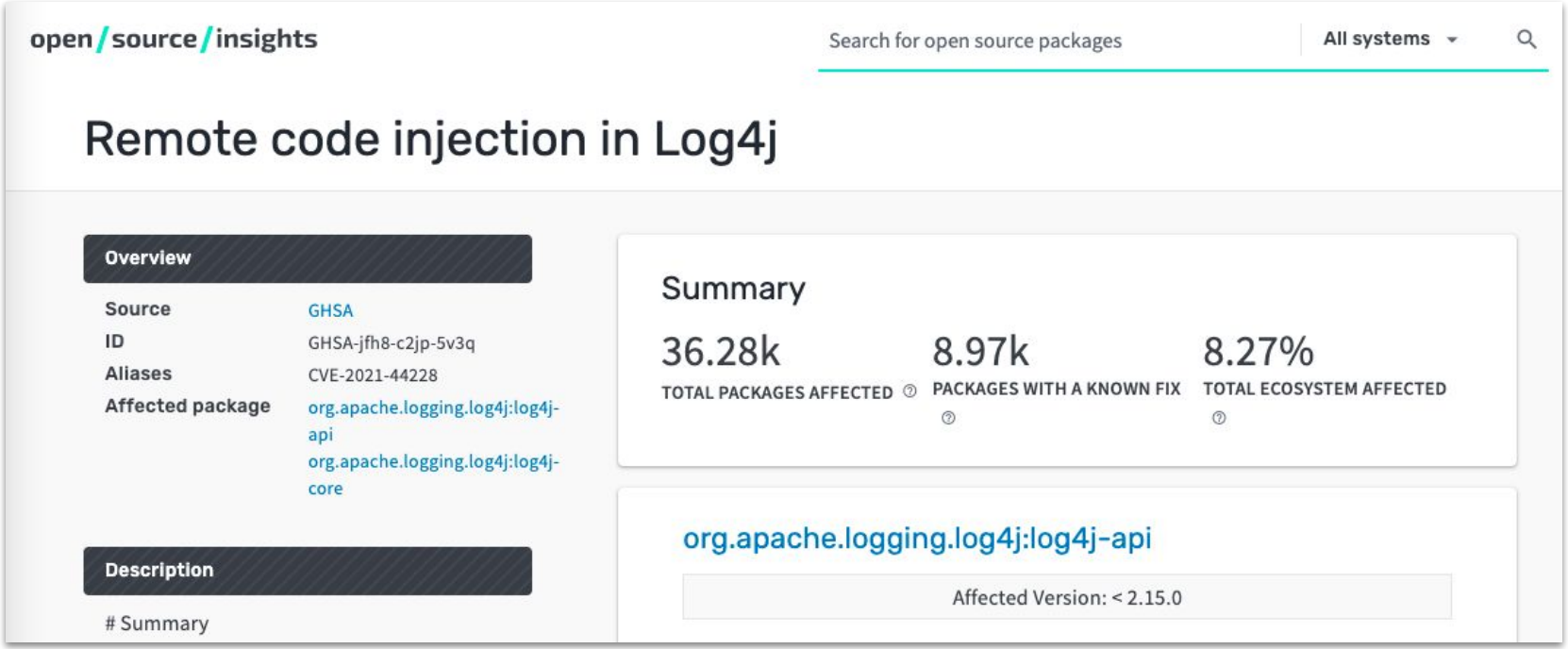
Open Source Projects 3rd Party

Development → Build → Test → Packaging → Policy Checks → Release/Operate

downstream / consumer

Open Source Projects Customers

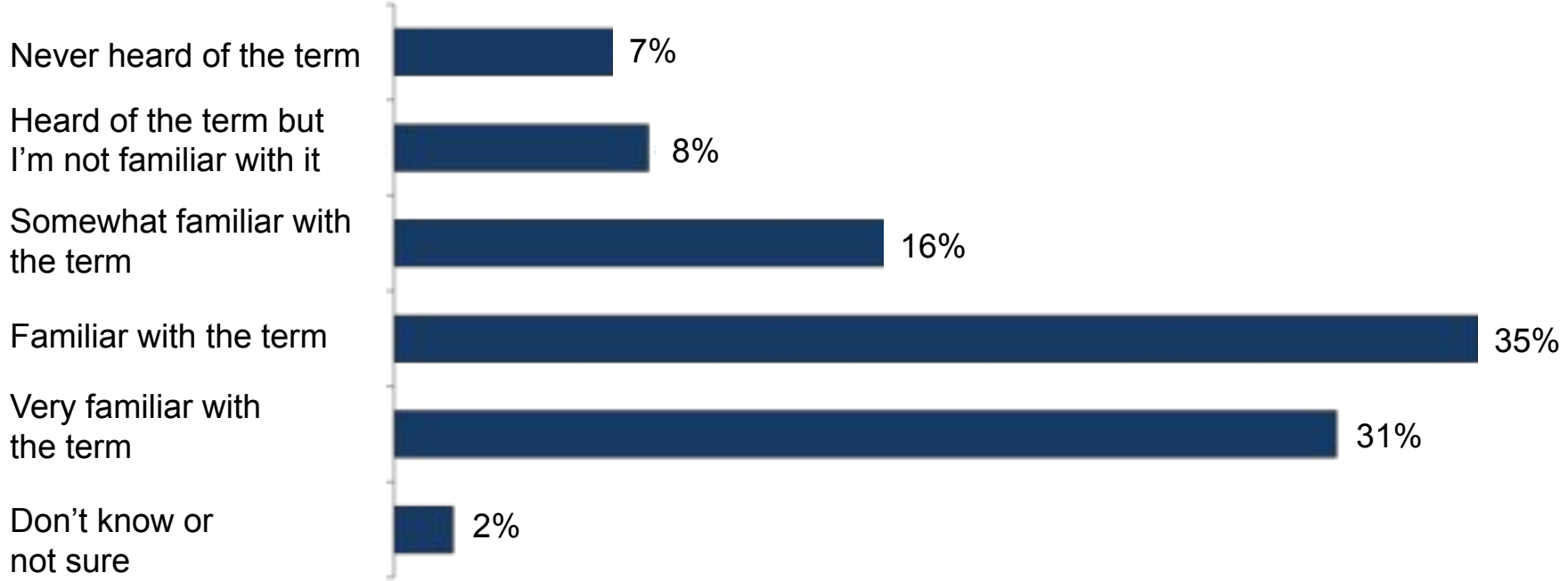
Challenge: Scaling up to the Open Source Ecosystem



Source: https://deps.dev/advisory/GHSA/GHSA-jfh8-c2jp-5v3q on 2022/1/10

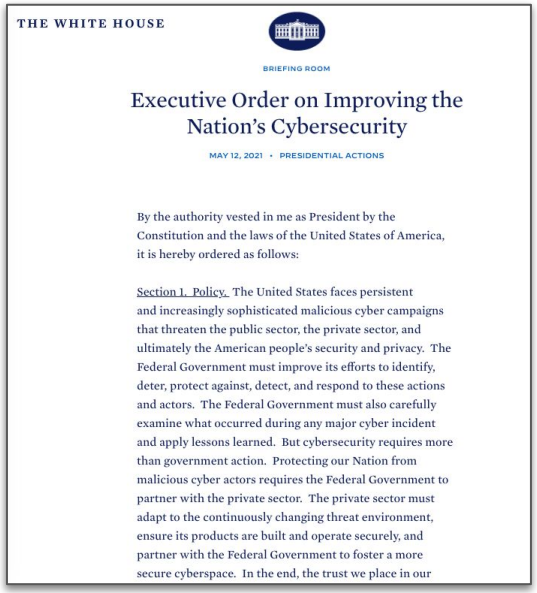
Industry Awareness of SBOM is emerging...

What is your organization's familiarity with a software bill of materials (SBOM)?



Sample Size = 361

Motivation



THE WHITE HOUSE

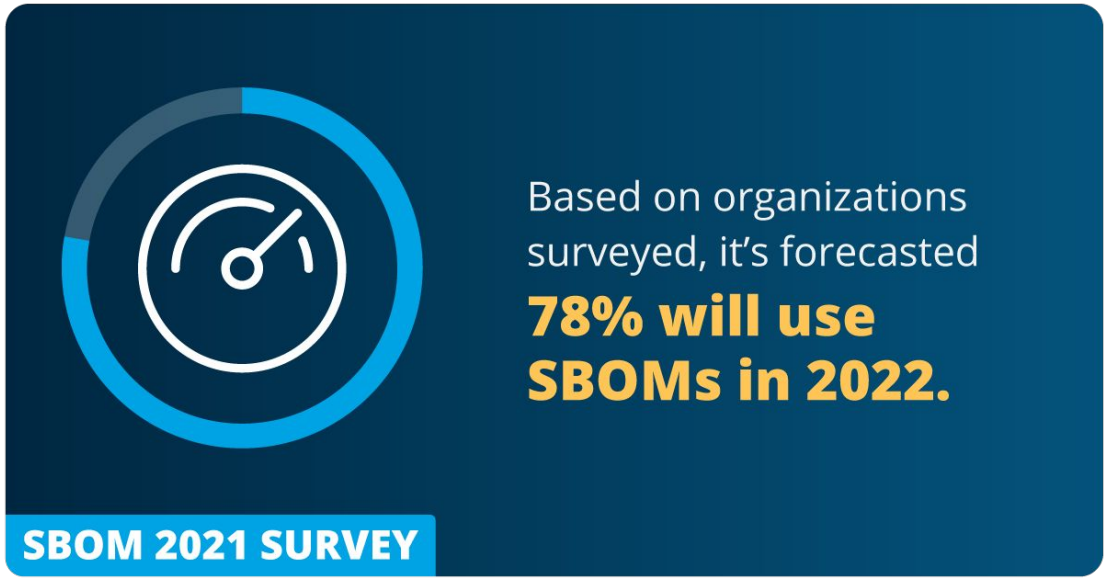
BRIEFING ROOM

Executive Order on Improving the Nation's Cybersecurity

MAY 12, 2021 • PRESIDENTIAL ACTIONS

By the authority vested in me as President by the Constitution and the laws of the United States of America, it is hereby ordered as follows:

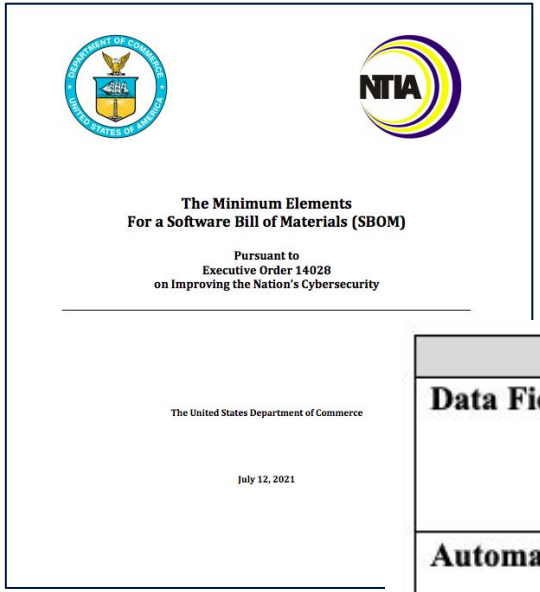
Section 1. Policy. The United States faces persistent and increasingly sophisticated malicious cyber campaigns that threaten the public sector, the private sector, and ultimately the American people's security and privacy. The Federal Government must improve its efforts to identify, deter, protect against, detect, and respond to these actions and actors. The Federal Government must also carefully examine what occurred during any major cyber incident and apply lessons learned. But cybersecurity requires more than government action. Protecting our Nation from malicious cyber actors requires the Federal Government to partner with the private sector. The private sector must adapt to the continuously changing threat environment, ensure its products are built and operate securely, and partner with the Federal Government to foster a more secure cyberspace. In the end, the trust we place in our



Doing this at scale requires standards and tools!

source: https://www.whitehouse.gov/briefing-room/presidential-actions/2021/05/12/executive-order-on-improving-the-nations-cybersecurity/
source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/

What is a Minimum SBOM?



The Minimum Elements
For a Software Bill of Materials (SBOM)

Pursuant to
Executive Order 14028
on Improving the Nation's Cybersecurity

The United States Department of Commerce

July 12, 2021

Minimum Elements	
Data Fields	Document baseline information about each component that should be tracked: Supplier, Component Name, Version of the Component, Other Unique Identifiers, Dependency Relationship, Author of SBOM Data, and Timestamp.
Automation Support	Support automation, including via automatic generation and machine-readability to allow for scaling across the software ecosystem. Data formats used to generate and consume SBOMs include SPDX, CycloneDX, and SWID tags.
Practices and Processes	Define the operations of SBOM requests, generation and use including: Frequency, Depth, Known Unknowns, Distribution and Delivery, Access Control, and Accommodation of Mistakes.

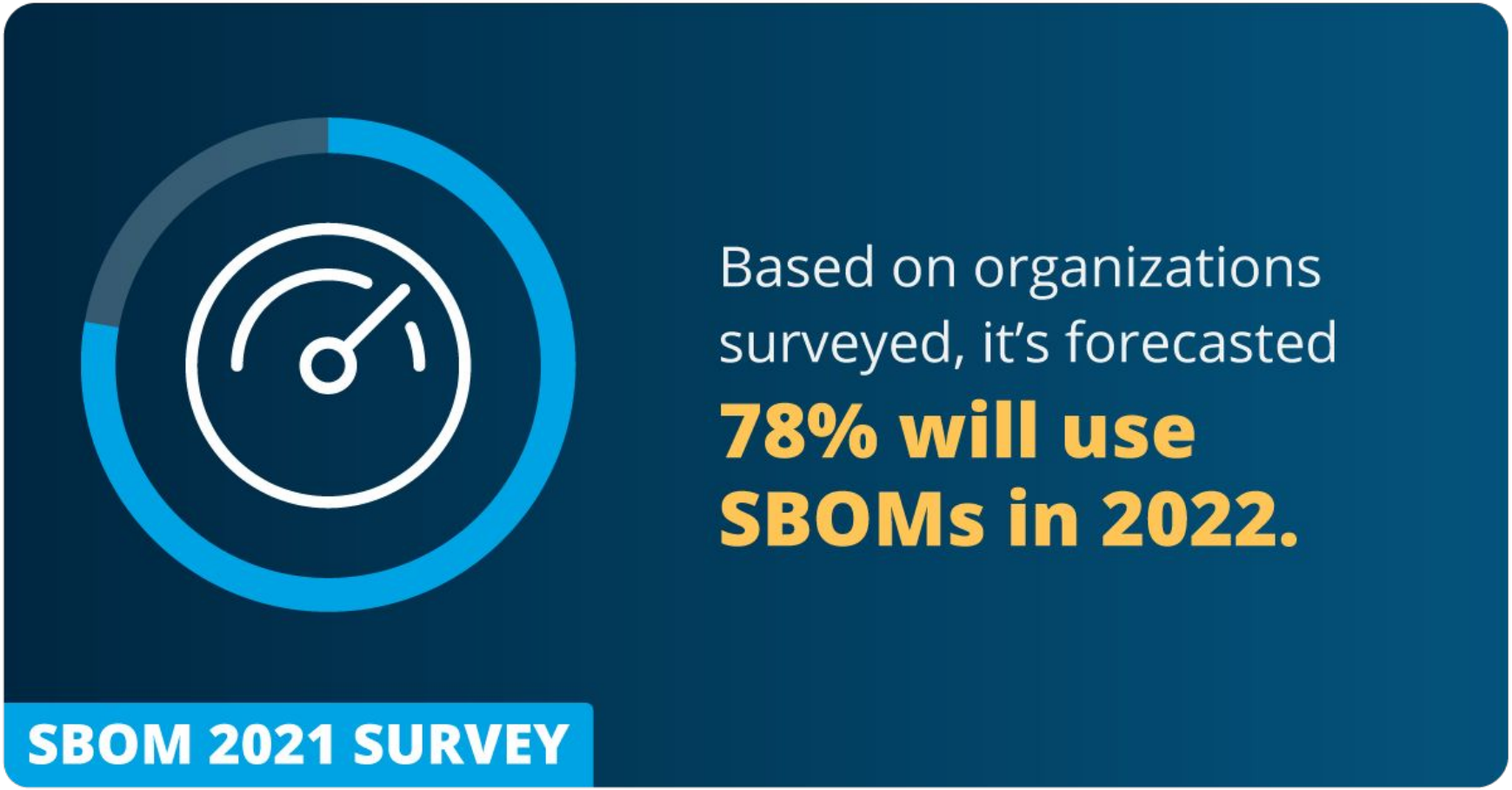
Source:https://www.ntia.gov/files/ntia/publications/sbom_minimum_elements_report.pdf.

What is the Minimum SBOM?

Data Field	Description
Supplier Name	The name of an entity that creates, defines, and identifies components.
Component Name	Designation assigned to a unit of software defined by the original supplier.
Version of the Component	Identifier used by the supplier to specify a change in software from a previously identified version.
Other Unique Identifiers	Other identifiers that are used to identify a component, or serve as a look-up key for relevant databases.
Dependency Relationship	Characterizing the relationship that an upstream component X is included in software Y.
Author of SBOM Data	The name of the entity that creates the SBOM data for this component.
Timestamp	Record of the date and time of the SBOM data assembly.

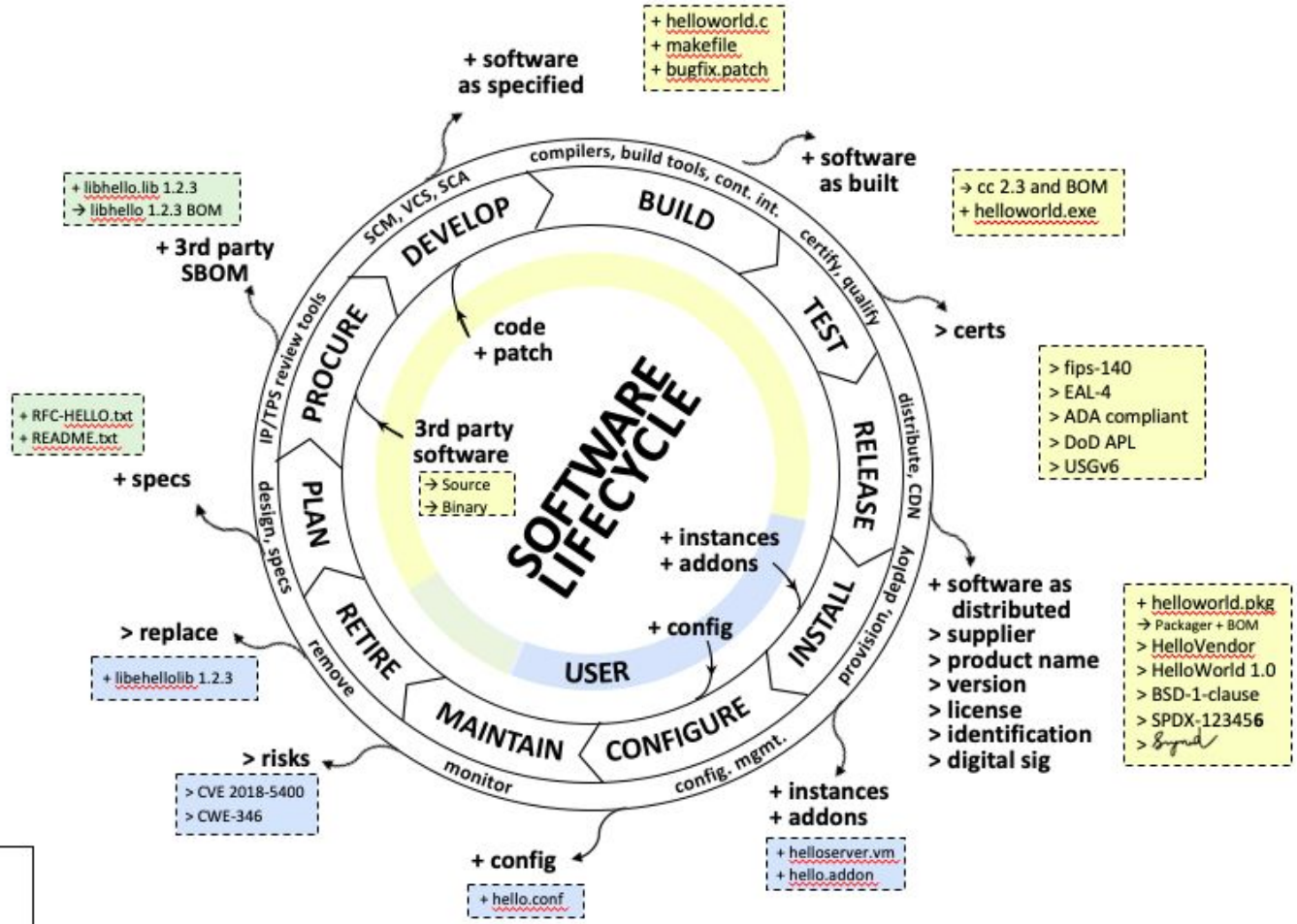
Source:https://www.ntia.gov/files/ntia/publications/sbom_minimum_elements_report.pdf.

Source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/



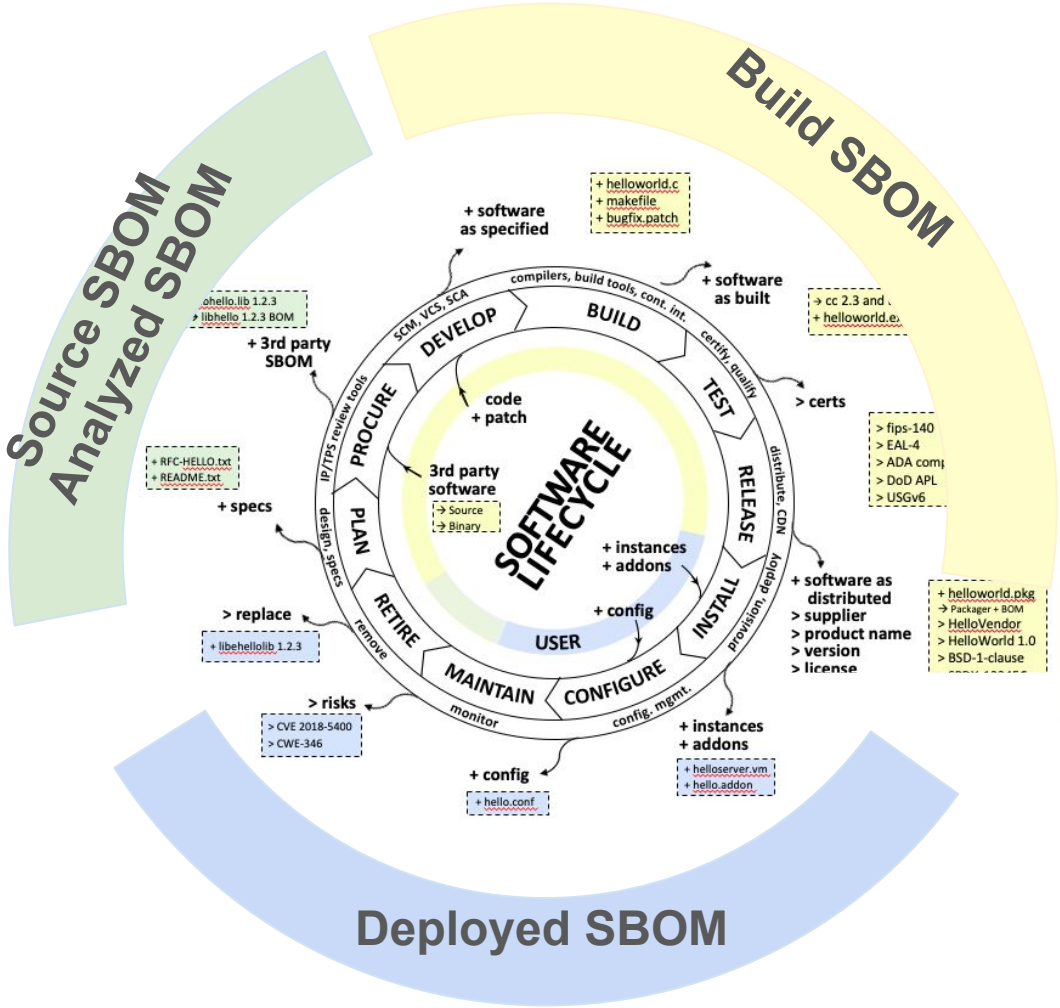
Source: https://www.linuxfoundation.org/tools/the-state-of-software-bill-of-materials-sbom-and-cybersecurity-readiness/

Software Lifecycle & Bill of Materials Generation



LEGEND
+ material
> metadata
→ reference
example BOM fragment
supplier | consumer | other

Derived from : NTIA's [Survey of Existing SBOM Formats and Standards]



Source SBOM - software sources used to build an executable image.

Analyzed SBOM - executable image to be integrated into deliverable. Created from 3rd party heuristics.

Build SBOM - List of components and relationships between dependent components assembled to create a product released from Supplier.

Deployed SBOM - Tracking configuration options on how a product has been deployed by User.

- Why the interest in SBOMs?
- What makes up an SBOM?
- **How to produce SBOMs for embedded systems?**

Embedded Projects Generating SBOMs

Zephyr's west spdx

Presentation / Demo:

https://www.youtube.com/watch?v=KYC3YpSu9zs

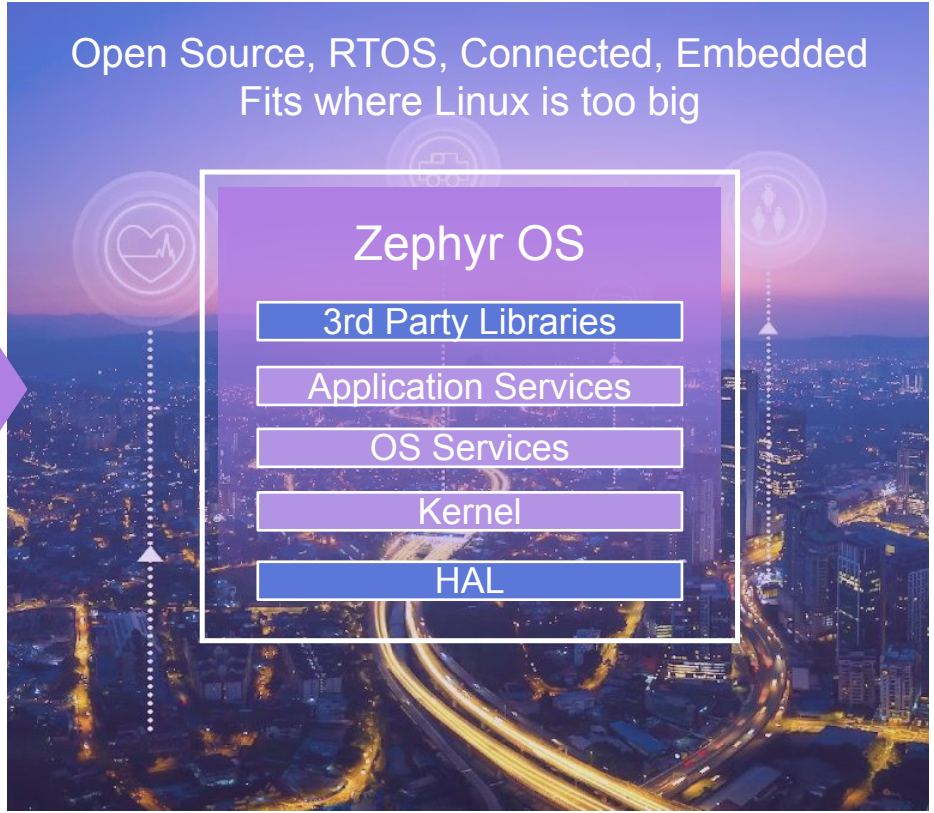
Yocto builds

Presentation / Demo:

https://www.youtube.com/watch?v=y0N4FnkwTOY

Case Study: **Zephyr**

- **Open source** real time operating system
- **Vibrant Community** participation
- Built with **safety and security** in mind
- **Cross-architecture** with broad SoC and development board support.
- **Vendor Neutral** governance
- **Permissively** licensed - Apache 2.0
- **Complete**, fully integrated, highly configurable, **modular** for **flexibility**
- **Product** development ready using LTS includes security updates
- **Certification** ready with Auditable



Example of Products Running Zephyr Today


Proglove


RUUVI Tag

Distancer


Keeb.io BDN9


Hati-ACE


Oticon More


Intellinium Safety Shoes


GNARBOX 2.0 SSD


Anicare Reindeer Tracker


Safety Pod

BLiXT solid state circuit breaker


Moto Watch 100


Point Home Alarm


Rigado IoT Gateway


HereO Core Box


Sentrius

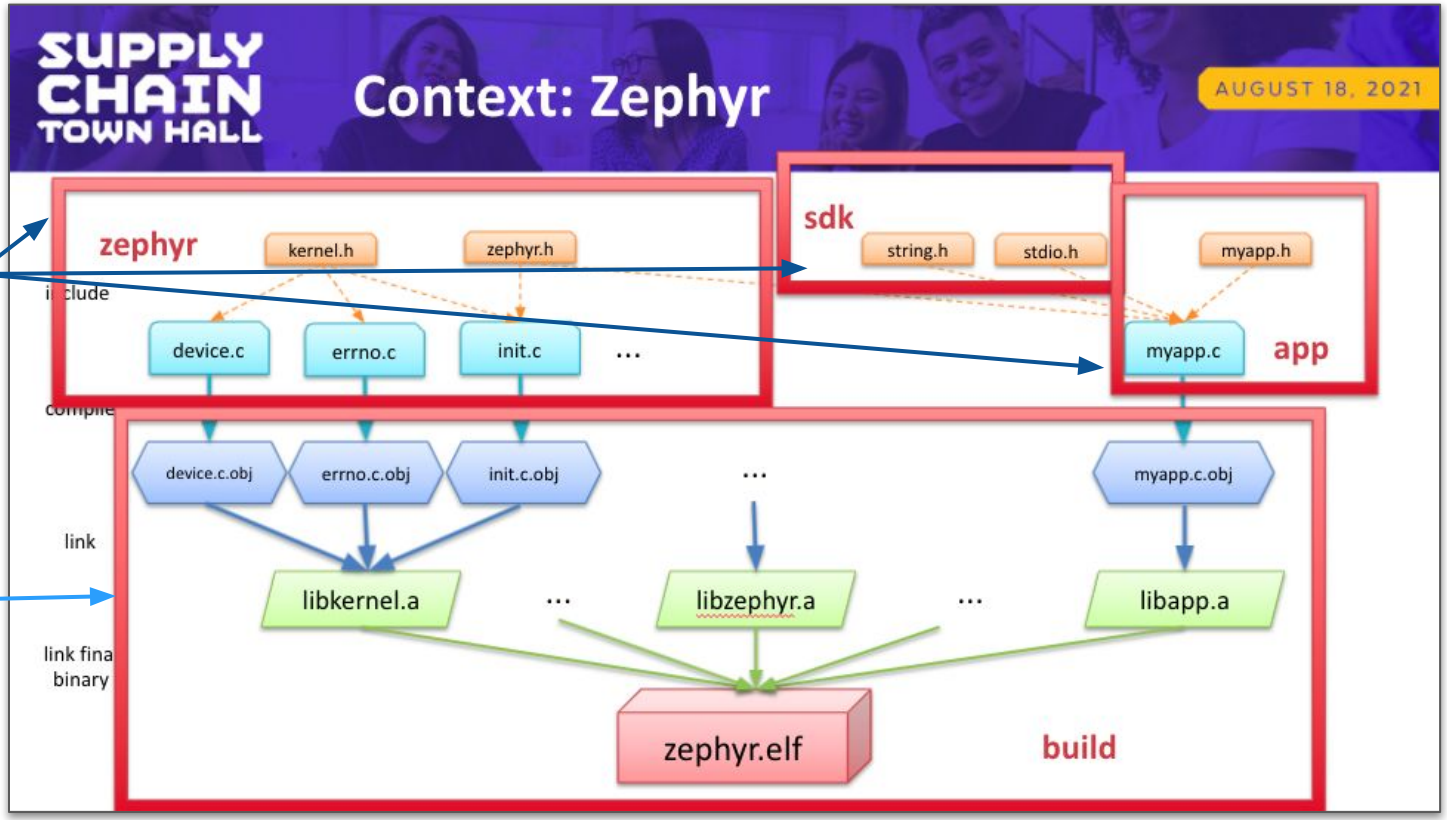
See.Sense AIR


Vestas Wind Turbine

One Line Config Change to Create SBOMs!

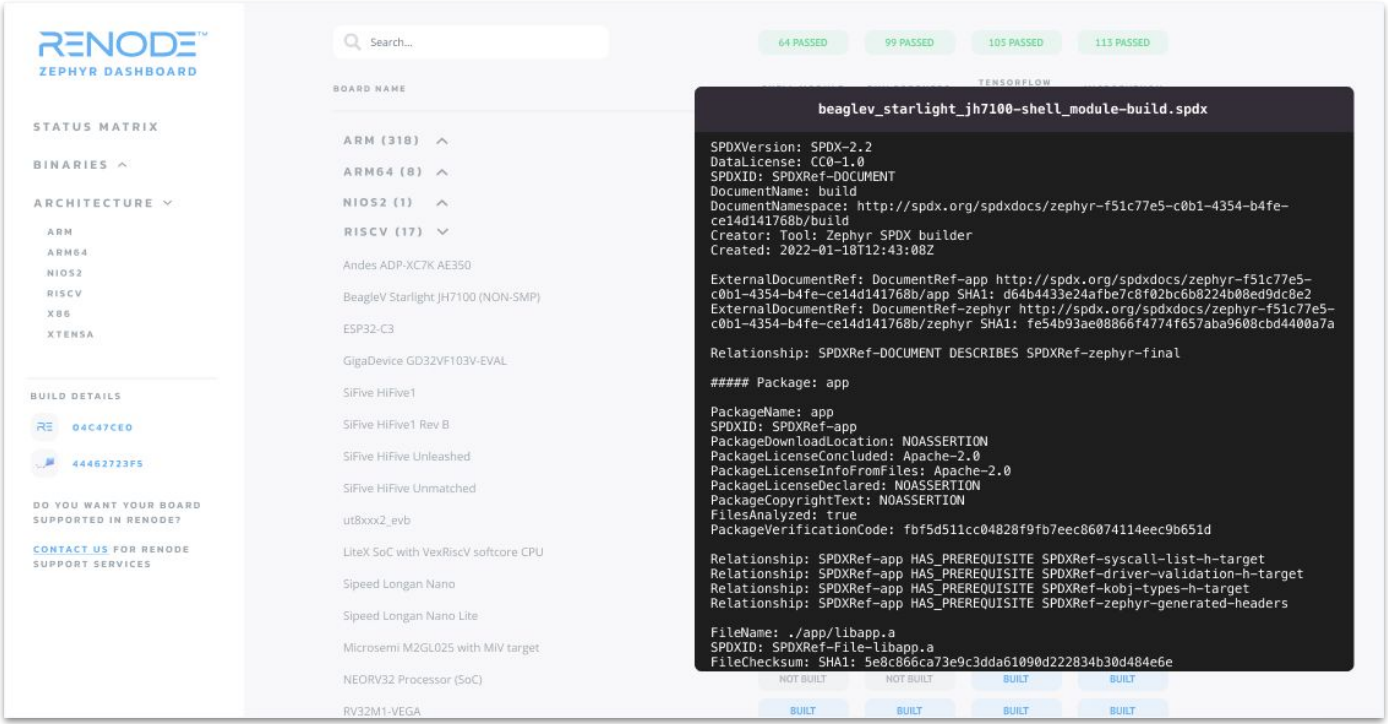
Source SBOM

Build SBOM



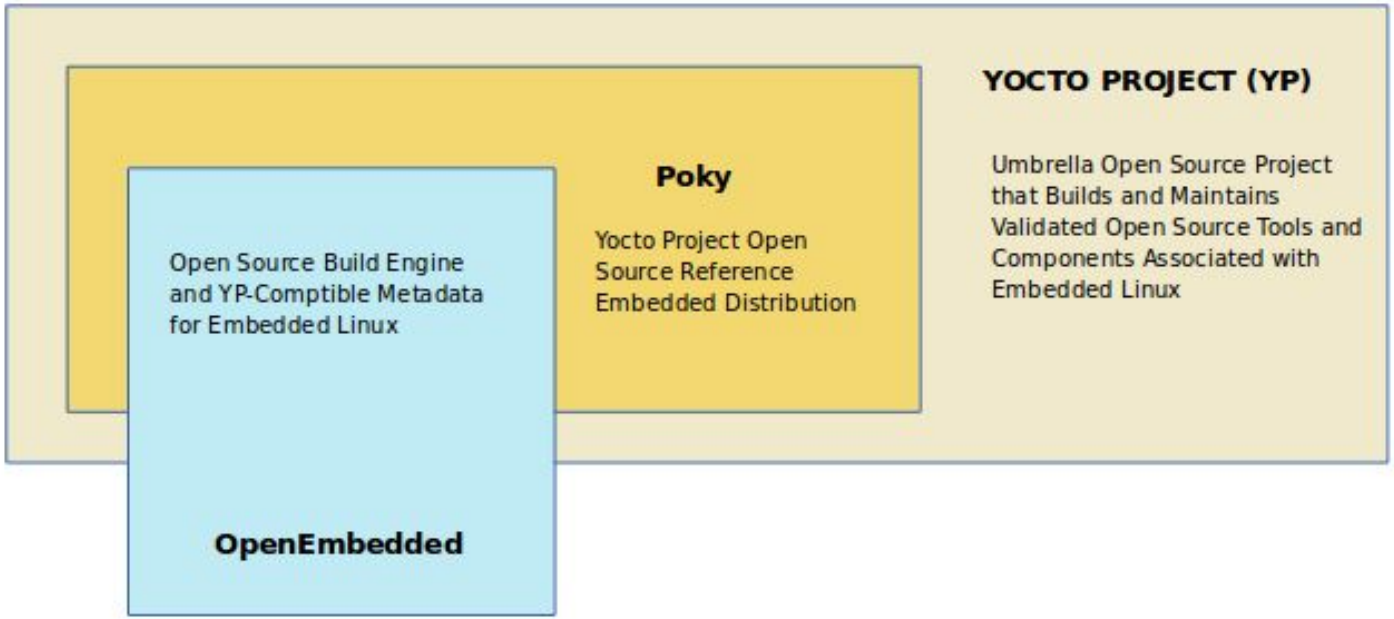
Learn more at: https://www.youtube.com/watch?v=KYC3YpSu9zs

SBOMs Included By Default … Automatically



Source:https://www.linux.com/featured/enhancing-supply-chain-security-for-embedded-systems-renode-dashboard-for-zephyr-rtos-adds-new-software-bill-of-materials-sbom-capabilities-by-default/

Case Study: Yocto & OpenEmbedded



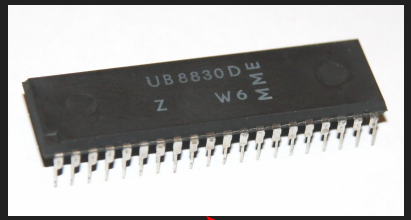
OpenEmbedded

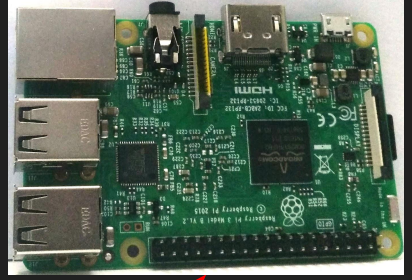
- Community project
- OpenEmbedded core layer
- Build system (bitbake)

Yocto Project

- Linux Foundation project
- Poky reference distribution
- Runs QA tests
- Manages release schedule
- Provides funding for personnel
- Documentation

Images





QEMU

Target Image

SDK

eSDK

buildtools

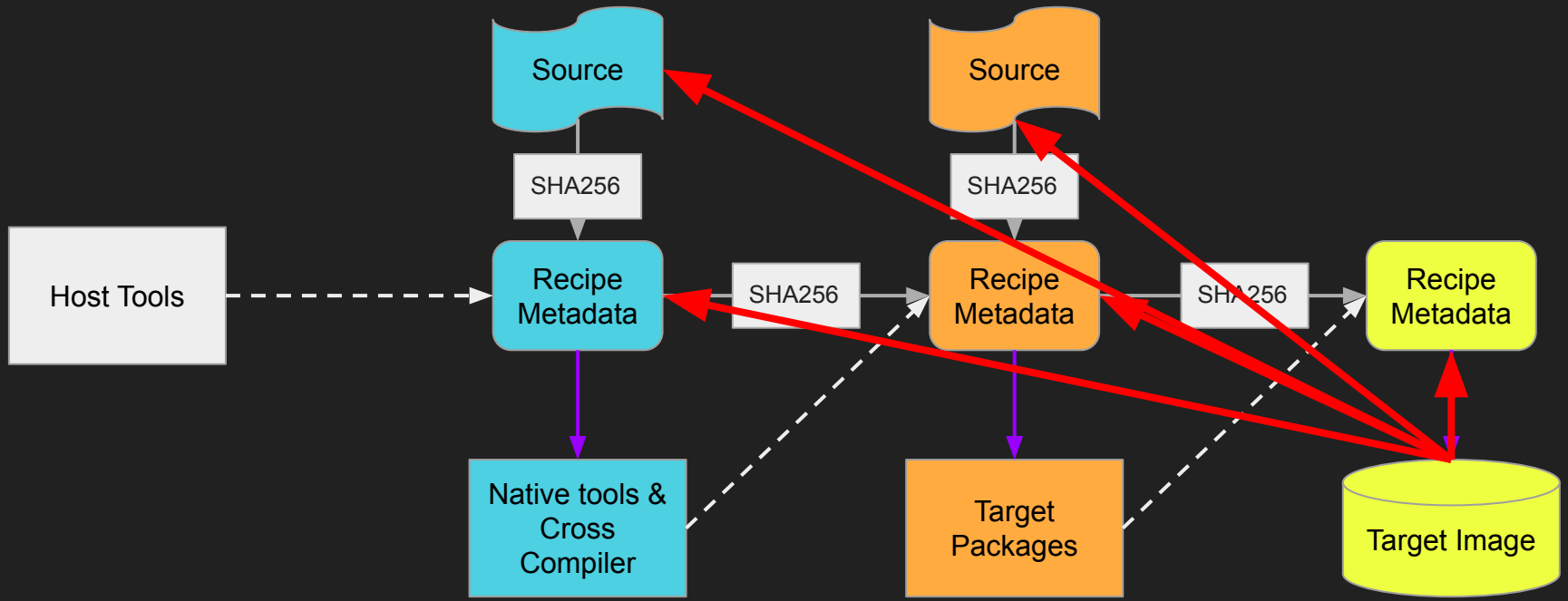
IPK

DEB

RPM

OPEN CONTAINER INITIATIVE

Simplified Build Flow



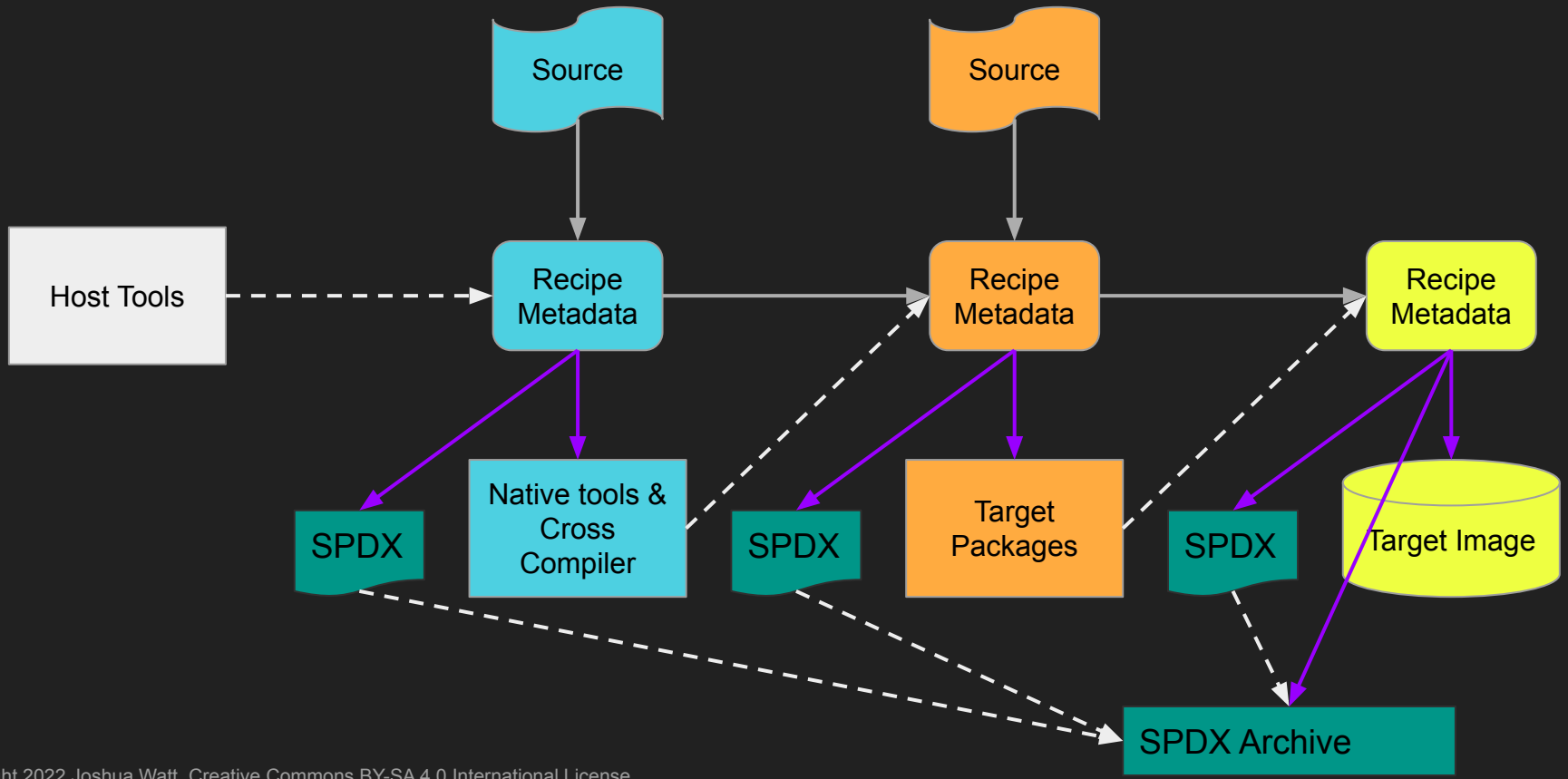
Recipe Metadata

Recipes already contain much of the data desired in a SBOM

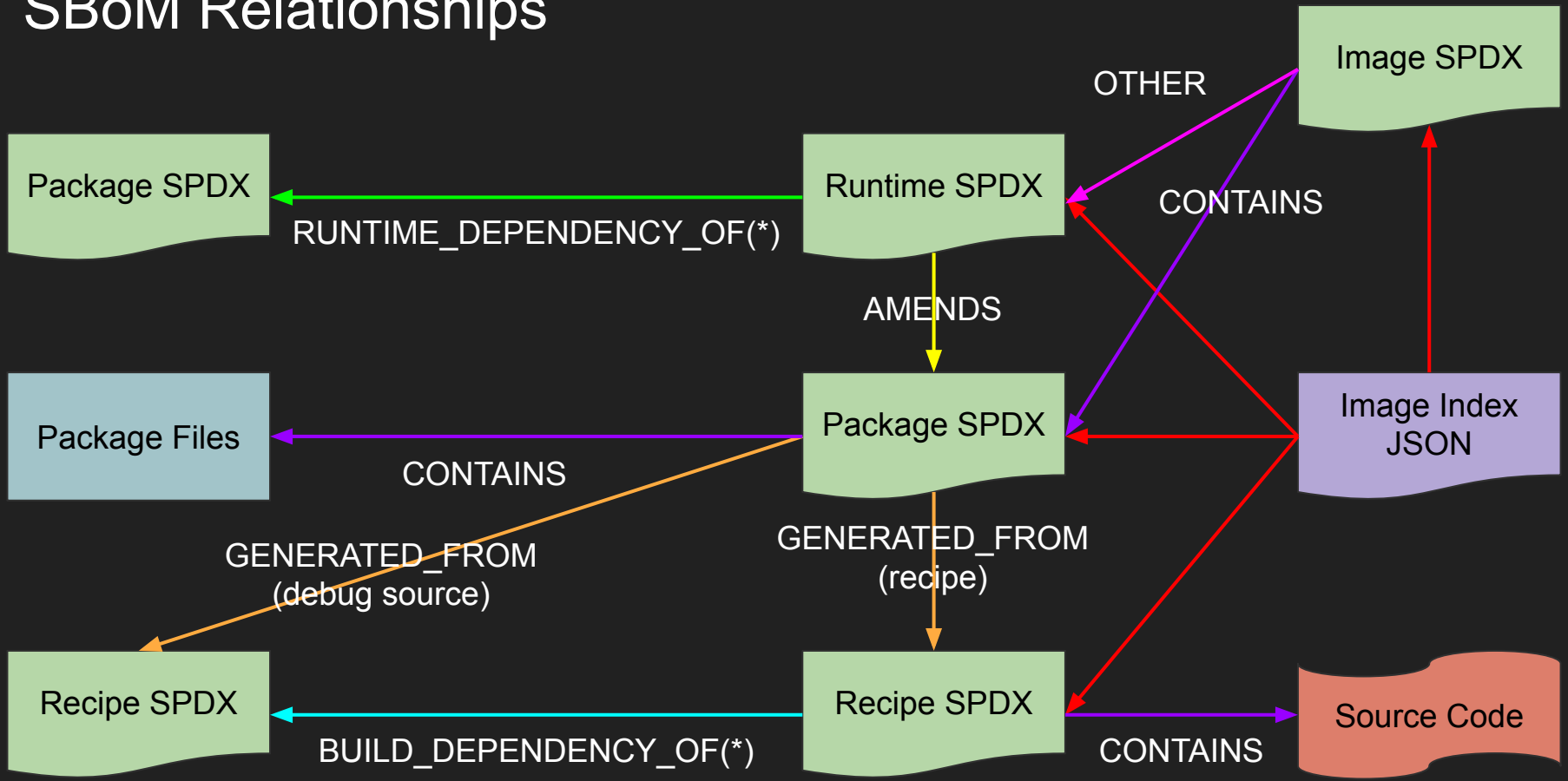
- Version
- Source code URL
- Licenses
- Build time dependencies
- Run time dependencies
- CVEs patched
- Source Files
- Package Files
- …

All of this information is authoritative (no guessing)

SPDX SBOM Generation with one line config change



SBoM Relationships



What can we generate SPDX SBOM documents for?

TL; DR - Anything we can build

- "On target" C/C++/Fortran etc. ✅
- "Host" build tools ✅
- Linux Kernel ✅
- Target images ✅
- SDKs ✅
- Container Images ✅
- VM Images ✅
- Rust 🚧
- Go 🚧

To learn more about Yocto & SBOM generation see:
https://www.youtube.com/watch?v=8X5PWa7A6pY

Yocto SPDX Features

- Declared License
  - With License Text if not a known SPDX license
- Homepage URL
- Download URL(s)
- CVEs fixed
- CPE
- Summary
- Description
- Source File Listing with Checksums
- Source file SPDX licenses
- Packages
- Package files with Checksums
- Package file GENERATED_FROM (from debug data)
- Build time dependencies
- Runtime dependencies
- Source code archive for analysis by other tools (e.g. Fossology)

SPDX: Embedded Focus from the Start

🐣 Born out of a need to exchange OSS component and license information - components and dependencies are the underpinning!

🎂 Recently celebrated its 10th birthday - 10 years of use cases produced rich set of dependency relationships.

🎉 SPDX 2.2 became ISO standard in 2021 (ISO/IEC 5962:2021)

Open weekly working group and monthly general meetings. Contributors welcome!

SPDX Supporters

anchore
Bitergia
Canvass Labs
Chain Guard
cisco
dynatrace
Eclipse Foundation
FOSSA
Foundries.io
Google
Guide Rails
here
Hitachi Inspire the Next
intel
Microsoft
MITRE
nexB
paloalto
SCANIA
SIEMENS
snyk
Source Auditor
Synopsys
Texas Instruments
TIDELIFT
TNG Technology Consulting
vmware
WNDRVR
wipro
XILINX

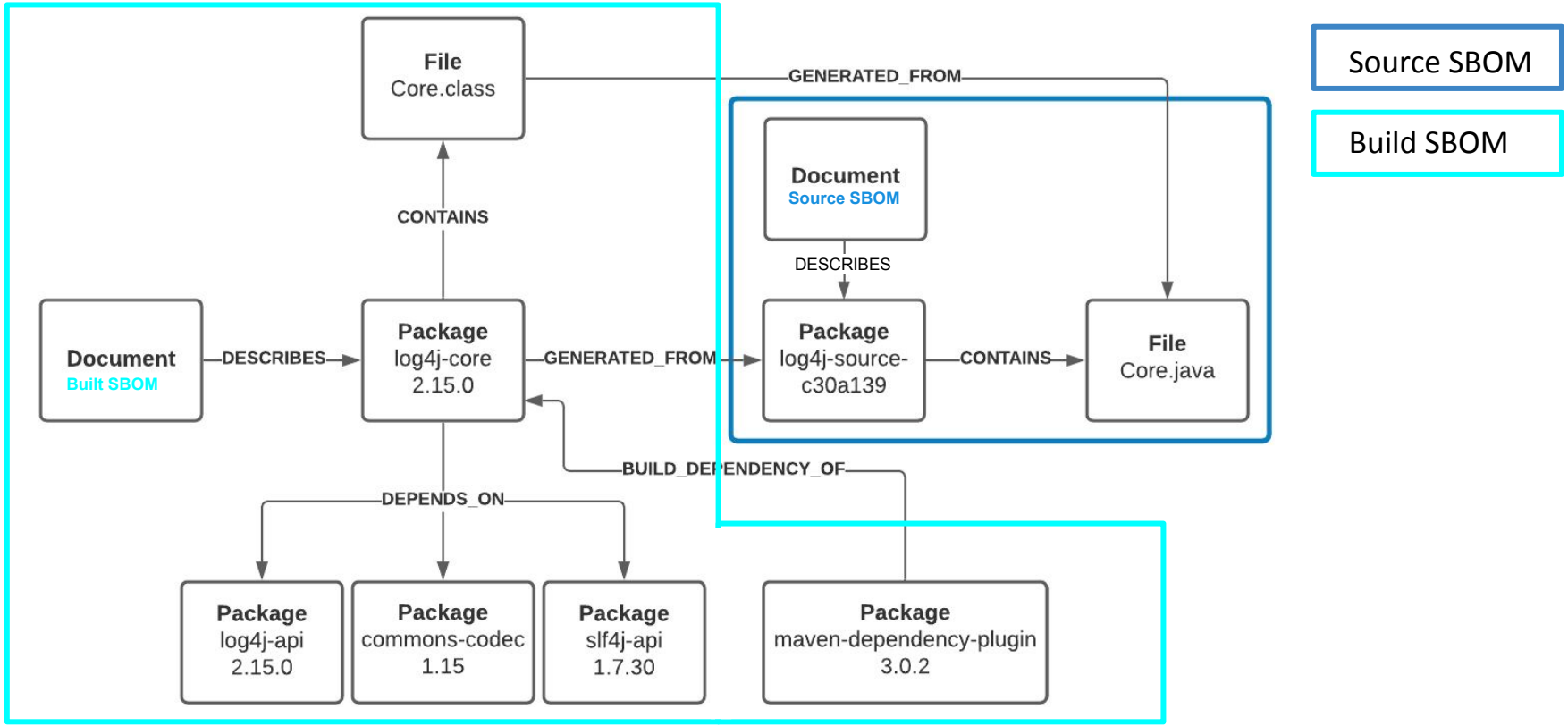
The Linux Foundation

SPDX Relationships Connect Dependencies Between Components and Between SBOMs

DESCRIBES	DEPENDENCY_OF	PREREQUISITE_FOR	GENERATES	VARIANT_OF
DESCRIBED_BY	RUNTIME_DEPENDENCY_OF	HAS_PREREQUISITE	TEST_OF	FILE_ADDED
CONTAINS	BUILD_DEPENDENCY_OF	ANCESTOR_OF	TEST_TOOL_OF	FILE_DELETED
CONTAINED_BY	DEV_DEPENDENCY_OF	DESCENDENT_OF	TEST_CASE_OF	FILE_MODIFIED
DYNAMIC_LINK	OPTIONAL_DEPENDENCY_OF	DOCUMENTATION_OF	EXAMPLE_OF	PATCH_FOR
STATIC_LINK	PROVIDED_DEPENDENCY_OF	BUILD_TOOL_OF	METAFILE_OF	PATCH_APPLIED
AMENDS	TEST_DEPENDENCY_OF	EXPANDED_FROM_ARCHIVE	PACKAGE_OF	OTHER
COPY_OF	OPTIONAL_COMPONENT_OF	DISTRIBUTION_ARTIFACT	DATA_FILE_OF	
DEPENDS_ON	DEPENDENCY_MANIFEST_OF	GENERATED_FROM	DEV_TOOL_OF	

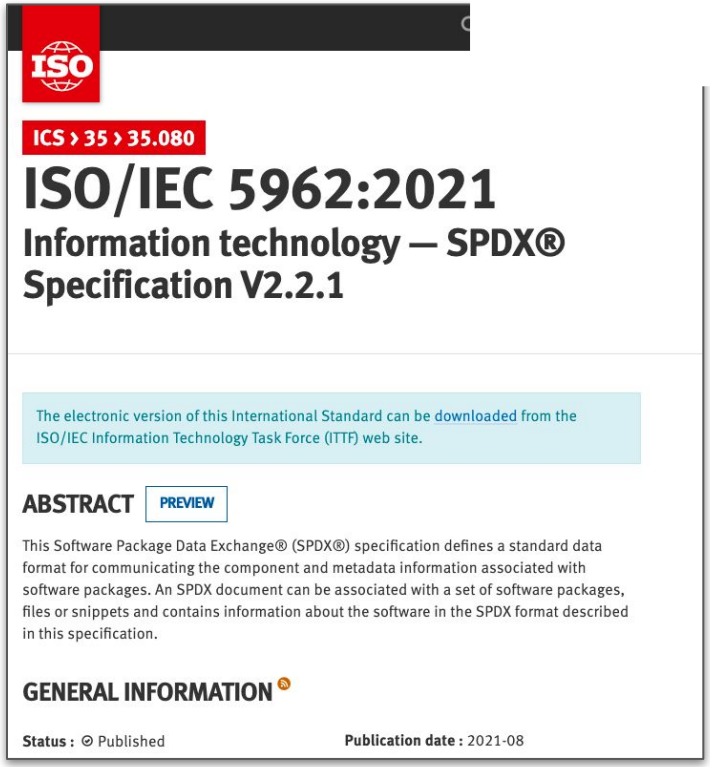
For more details see: : https://spdx.github.io/spdx-spec/relationships-between-SPDX-elements/

SPDX



ISO/IEC 5962:2021

- SPDX is became an ISO/IEC standard in 2021!
- Specification is freely available from [ITTF site]
- Future updates are live tracked at: https://spdx.github.io/spdx-spec
- For more information on participating in next revisions see https://spdx.dev/



Source: https://www.iso.org/standard/81870.html
accessed on 2021/11/19

SPDX 2.3: 2022/08

I.1 Differences between V2.3 and V2.2.2

V2.3 has added new fields to improve the ability to capture security related information and to improve interoperabiility with other SBOM formats.

Key changes include:

- Added fields to Clause 7 (Package Information) to describe "Primary Package Purpose" and standardize recording of "Built Date", "Release Date", "Valid Until Date".
- Added hash algorithms (SHA3-256, SHA3-384, SHA3-512, BLAKE2b-256, BLAKE2b-384, BLAKE2b-512, BLAKE3, ADLER32) to the set recognized by 7.10 (Package Checksum field) and 8.4 (File checksum field)
- Update Clause 7, 8, and 9 to make several of the licensing properties optional rather than requiring the use of "NOASSERTION" when no value is provided.
- Update Clause 11 to add the new relationship types: REQUIREMENT_DESCRIPTION_FOR and SPECIFICATION_FOR.
- Update Annex B (License matching guidelines and templates) to use the License List XML format
- Update Annex F (External Repository Identifiers) to expand security references to include advisory, fix, URL, SWID. Expand persistent identifiers to include gitoid.
- Update Annex G (SPDX Lite Profile) to include NTIA SBOM mandatory minimum fields as required.
- Update Annex H to documented how the snippet information in files to be consistent with REUSE recommendations.
- Added Annex K (How To Use SPDX in Different Scenarios) to illustrate linking to external security information, and illustrate how the NTIA SBOM mandatory minimum elements map to SPDX fields.

Source: https://spdx.github.io/spdx-spec/v2.3

To Learn More:

Software Bill of Materials (SBOM) Guidance:

- https://www.ntia.gov/SBOM
- https://www.cisa.gov/sbom

Zephyr SBOM generation:

- Documentation: Generate Software Bill of Materials with West
- Presentation: Generating SBOMs for IoT at Build Time
- Presentation: Zephyr Developer Summit see: https://sched.co/10CF4

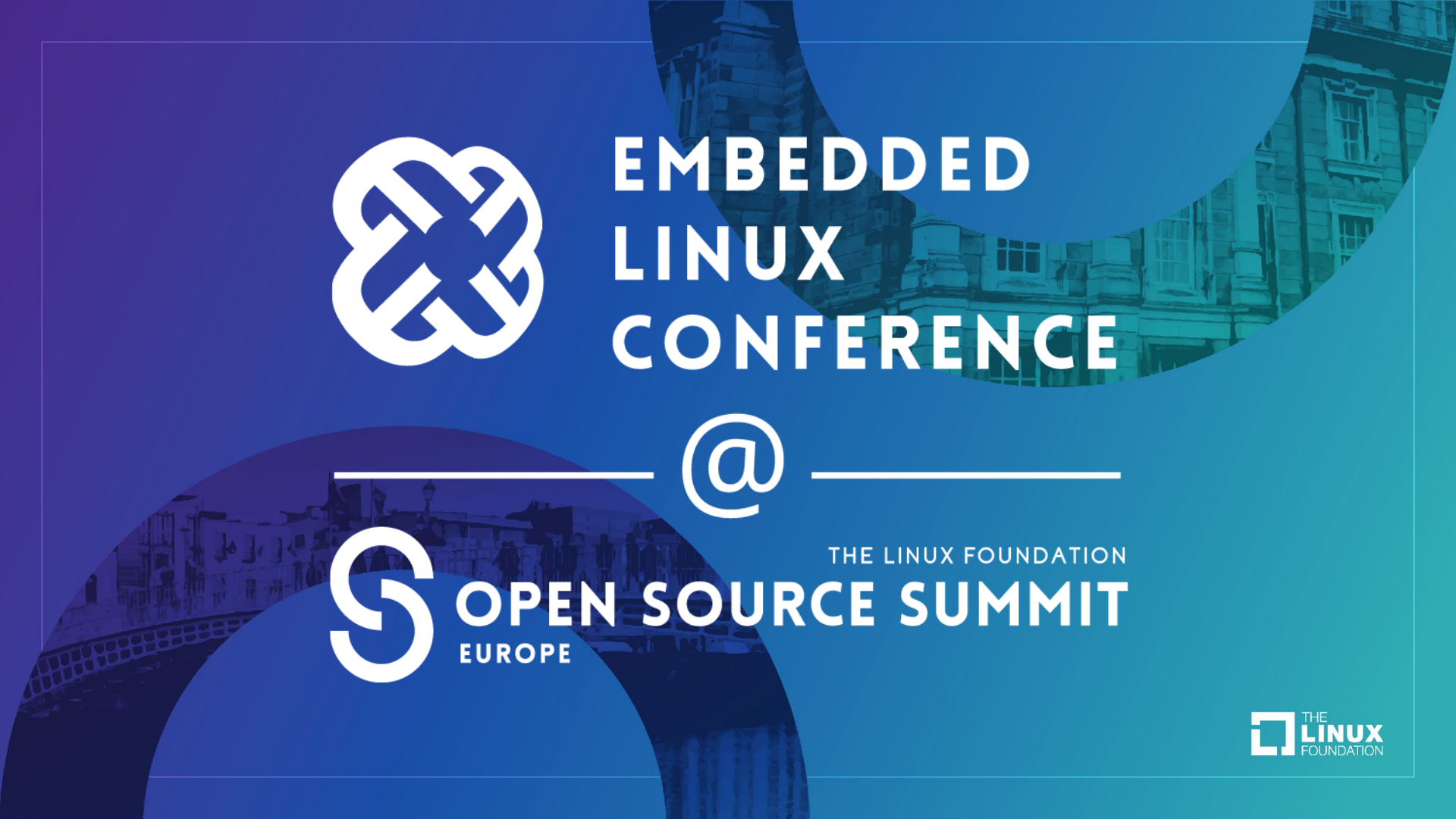
Yocto SBOM generation:

- Documentation: create-spdx in Release 3.4 (honister)
- Presentation: Software Supply Chain with the Yocto Project
- Presentation: SPDX in the Yocto Project

SPDX:

- https://spdx.dev/
- Documentation: https://spdx.github.io/spdx-spec/v2.3

THE LINUX FOUNDATION


EMBEDDED
LINUX
CONFERENCE
@
THE LINUX FOUNDATION
OPEN SOURCE SUMMIT
EUROPE
THE
LINUX
FOUNDATION